Field Test Program for Long-Term Operation of a COHPAC® System for Removing Mercury from Coal-Fired Flue Gas

Quarterly Technical Report
Reporting Period: October 1, 2004–December 31, 2004

Principal Authors:
Jean Bustard, Charles Lindsey, Paul Brignac, Travis Starns, Sharon Sjostrom, Trent Taylor, Cindy Larson

ADA-ES, Inc.
8100 SouthPark Way, Unit B
Littleton, Colorado 80120

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DISCLAIMER

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ABSTRACT

With the Nation's coal-burning utilities facing the possibility of tighter controls on mercury pollutants, the U.S. Department of Energy is funding projects that could offer power plant operators better ways to reduce these emissions at much lower costs. Sorbent injection technology represents one of the simplest and most mature approaches to controlling mercury emissions from coal-fired boilers. It involves injecting a solid material such as powdered activated carbon into the flue gas. The gas-phase mercury in the flue gas contacts the sorbent and attaches to its surface. The sorbent with the mercury attached is then collected by the existing particle control device along with the other solid material, primarily fly ash.

During 2001, ADA Environmental Solutions (ADA-ES) conducted a full-scale demonstration of sorbent-based mercury control technology at the Alabama Power E.C. Gaston Station (Wilsonville, Alabama). This unit burns a low-sulfur bituminous coal and uses a hot-side electrostatic precipitator (ESP) in combination with a Compact Hybrid Particulate Collector (COHPAC®) baghouse to collect fly ash. The majority of the fly ash is collected in the ESP with the residual being collected in the COHPAC® baghouse. Activated carbon was injected between the ESP and COHPAC® units to collect the mercury.

Short-term mercury removal levels in excess of 90% were achieved using the COHPAC® unit. The test also showed that activated carbon was effective in removing both forms of mercury–elemental and oxidized. However, a great deal of additional testing is required to further characterize the capabilities and limitations of this technology relative to use with baghouse systems such as COHPAC®. It is important to determine performance over an extended period of time to fully assess all operational parameters.

The project described in this report focuses on fully demonstrating sorbent injection technology at a coal-fired power generating plant that is equipped with a COHPAC® system. The overall objective is to evaluate the long-term effects of sorbent injection on mercury capture and COHPAC® performance. The work is being done on one-half of the gas stream at Alabama Power Company's Plant Gaston Unit 3 (nominally 135 MW). Data from the testing will be used to determine:

1. If sorbent injection into a high air-to-cloth ratio baghouse is a viable, long-term approach for mercury control; and
2. Design criteria and costs for new baghouse/sorbent injection systems that will use a similar, polishing baghouse (TOXECON™) approach.

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EXECUTIVE SUMMARY

ADA-ES began work on a Cooperative Agreement with the Department of Energy in September 2002 to fully evaluate activated carbon injection (ACI) in conjunction with a high-ratio baghouse (COHPAC®) for mercury control. The work was being conducted at Alabama Power Company's Plant Gaston. During the three-year project, a powdered ACI system was installed and tested at the plant for a continuous one-year period. ADA-ES' responsibilities for managing the project include engineering, testing, economic analysis, and information transfer functions.

During the tenth reporting quarter, October through December 2004, progress on the project was made in the following areas:

- Received and analyzed bag test results

INTRODUCTION

Cooperative Agreement No. DE-FC26-02NT41591 was awarded to ADA-ES to demonstrate activated carbon injection (ACI) technology on a coal-fired boiler equipped with a COHPAC® baghouse. Under the contract, ADA-ES is working in partnership with DOE/NETL, Alabama Power, and EPRI.

A detailed report will be prepared at the end of the test. Quarterly reports will be used to provide project overviews and technology transfer information.

Team Members

This program is made possible by significant cost-share support from the following companies:

- Duke Power
- EPRI
- Southern Company and Alabama Power Company
- Hamon Research-Cottrell, Inc.
- Allegheny Power
- Ontario Power Generation
- TVA
- Duke Power
- Arch Coal, Inc.
- ADA-ES, Inc.

A group of highly qualified individuals and companies was assembled to implement this program. Project team members include:

- ADA-ES, Inc.
- Southern Research Institute
- Grubb Filtration Testing Services, Inc.
- Reaction Engineering International

EXPERIMENTAL

None to report this quarter.

RESULTS AND DISCUSSION

The field test portion of the program was completed in July 2004. The original test plan was adapted to the operating conditions at the host site. These changes were documented in Report No. 41591R04, but primarily consisted of extending the baseline and optimization tests and modifying the injection scheme. The test plan for this program has five primary tasks:

1. Design and install an activated carbon injection system capable of continuous operation for up to one year.
2. Install a mercury analyzer capable of long-term, continuous operation. This analyzer is referred to as a Semi-Continuous Emissions Monitor (S-CEM).
3. Evaluate the long-term performance of carbon injection upstream of COHPAC® for mercury control. This task has two separate test periods:
   a. The first test (up to six months) was conducted using the existing set of bags.
   b. The second test (up to six months) was conducted on a set of new bags made from advanced fabrics.
4. Perform short-term tests of alternative sorbents.
5. Document test procedures and results, and complete reporting and management requirements.

Tasks 1, 2, 3, and 4 have been completed. Task 5 is in progress.

Long-Term Performance Evaluation of Original Bags (July 19–November 25, 2004)

Analysis of Used Filter Bags

Grubb Filtration Testing Services (GFTS) was contracted to perform bag inspections, bag testing, procurement of the new high-perm bags and Quality Assurance testing of the new bags. A report with results from testing on used bags was received during this reporting period. A brief summary of this report is presented here, with the full report included as Appendix A.

Testing on this program began in March 2003. Testing was conducted with filter bags that were already in place (Long-Term Test on Original Bag). Information about these bags can be found in Table 1. The Gaston 3B baghouse has two compartments and each compartment has two bag modules. There are 544 filter bags in each module, for a total of 2,176 bags. The front modules are referred to as 3B10 and 3B20. The back modules are called 3B11 and 3B21.

Table 1. History of Original Filter Bag at Start of Long-Term Test in March 2003

Modules	Front (3B10 & 3B20)	Rear (3B11 & 3B21)
Bag Supplier	Midwesco	BHA
Date Installed	11/4/00	11/30/01
Length of Service*	18,809 hr	9,678 hr

* Exposure Hours (hours bags exposed to flue gas including time when bypass damper is partially opened) from Southern Research Institute summary through March 31, 2003, assuming continuous operation after outage.

Two used bags, one each from a front and rear module, were removed on March 11, 2003, and sent to GFTS for analysis to determine their baseline conditions. The results from these tests are documented in GFTS Report No. 3789, which is included as Appendix A. At that time, six (6) new 2.7-denier bags were installed, three in Module B20 and three in Module B21. Once the long-term sorbent injection testing was completed, additional bags were removed and analyzed by GFTS. These results are documented in GFTS Report No. 3919, included as Appendix B.

Summary and Conclusions

Except for having somewhat lower permeability values, the original replacement bags (B20 and B21) that were exposed to carbon injection during most of their final 6,266 hours of service had properties that were similar to those of the Gaston 3 OEM bags tested in 1998–2000 after comparable lengths of service without carbon injection.

In particular, the activated carbon has had no significant effect on either the fabric strength or pH values.

High-Perm Bag Test (December 15, 2003–June 4, 2004)

Particulate Matter Emission Tests (September 9, 2004)

One important test that was inadvertently omitted while the Ontario Hydro tests were being performed in May 2004 was a measurement of outlet emissions with the high-perm bags. These tests were conducted by Weston Solutions on September 9, 2004. A set of three emission tests, following EPA Method 17, were made in the outlet duct of the Unit 3B COHPAC® baghouse. The results from these tests and inlet tests conducted in May 2004 can be seen in Table 2.

The inlet measurements show the wide variability in inlet loading, ranging from 0.003 to 0.241 gr/dscf. The outlet mass loading, mean of 0.024 gr/dscf, was higher than expected. This outlet emission concentration is within the range that would be expected at the inlet to the baghouse. Typical emissions from previous tests at Gaston with 2.7-denier bags were <0.003 gr/dscf. Emissions from a COHPAC® baghouse installed at TXU's Big Brown Station with both 2.7- and 7.0-denier bags were also much lower than the 0.024 gr/dscf measured in these tests.

It is suspected that bag failures are the cause of the higher than expected outlet emissions. In the spring outage, several bags that were improperly installed in December were found and replaced. Additional problems could have occurred between March and September. Unfortunately, it is very difficult to gain permission to isolate compartments when the unit is online. The first opportunity to conduct a bag inspection will be late January 2005.

Table 2. Results from Method 17 Particulate Emission Tests with High-Perm Bags at the Unit 3B COHPAC® Inlet in May 2004 and the Unit 3B COHPAC® Outlet in September 2004

Location/Test Dates	Run 1	Run 2	Run 3	Mean
Inlet/May 2004	0.241	0.064	0.003	0.103
Outlet/September 2004	0.035	0.022	0.015	0.024

Alternative Carbon Tests (June 7–July 2, 2004)

Evaluating carbons from different manufacturers was the final testing task and was included to broaden the options of suppliers and sorbents evaluated in this program. Eight different sorbents were tested. A summary of the sorbent provider, product name, projected bulk commercial pricing, and a brief product description can be found in Table 3. Three of the sorbents were evaluated over a several-day period. The other five sorbent tests lasted as long as necessary to feed out about 500 pounds of material. When possible, more than one feed rate was evaluated. Test results, presented in Table 4 and Figure 1, are discussed below.

Table 3. Alternative Carbon Product Description

Company	Product Name	Projected Price ($/lb)	Product Description
NORIT Americas	E3	$0.65	Enhanced FGD activated carbon designed for low-halogen flue gas
RWE	HOK Super	$0.35	Activated lignite
General Technologies	PC-800 (FJ045)	$0.34	PAC made from bituminous coal
Superior Adsorbents, Inc.	Merqsorb	$0.40	PAC made from bituminous coal
CARBOCHEM	MGF-20	$0.15	Low-cost material
Donau	Desorex DX 400C	$0.34	
Southern Company	PSDF Ash	TBD	Ash from pilot-scale gasifier
Southern Company	Proprietary mix	TBD	

Analysis and Interpretation of Table 4 and Figure 1

- Removal efficiency measured at each of the conditions tested is shown in Table 4. In most cases, the removal efficiency is shown with a "<" symbol before the value. This convention is used to indicate that this value was the highest removal efficiency measured during the test. Because these tests were short and conditions were not stable, this value is not necessarily the steady state value that would be achieved if longer testing was possible.
- Figure 1 graphically presents the data in Table 4. This graph also shows results from parametric tests conducted in the Phase I program in 2001.
- The results indicate that NORIT's E3, RWE's HOK Super, General Technologies' PC-800 and Southern Company's proprietary mix all had similar performance and were identical to performance of standard activated carbons tested in the more comprehensive parametric test series in 2001. SAI's Merqsorb had a slightly lower mercury removal than the best performers, but taking into account the variable baseline mercury removal that occurred during this test, this sorbent performance should be considered similar to the others.
- The other three sorbents were not as effective for mercury removal. The Donau product had good mercury removal, 50%, at an injection concentration of 1.6 lbs/MMacf, but it did not reach the 70% range that some of the others did.

- Southern Company's PSDF ash showed that it is capable of adsorbing mercury, but that it might take high injection concentrations to reach removal efficiencies greater than 70%.
- The CARBOCHEM low-cost sorbent, MGF-20, performed poorly achieving only 20% mercury removal at greater than 3.0 lbs/MMacf. CARBOCHEM responded to our request for sorbents with four different options, one of which was MGF-20. This performance was surprising because ADA-ES has tested other CARBOCHEM sorbents that showed very good performance, similar to other standard activated carbons.
- The overall conclusions from these tests are:
    - Most standard, high quality activated carbon performed similarly at this site;
    - The low-cost sorbent and ash-based sorbents were not very effective at removing mercury; and
    - Chemically-enhanced sorbents do not appear to offer any benefits over standard activated carbons.

Table 4. Alternative Carbon Parametric Test Results

Carbon ID	Injection Rate (lbs/h)	Injection Conc. (lbs/MMacf)	Removal Efficiency (%)
A	20	0.6	<60
A	28	0.8	<70
A	35	1.0	<75
A	20	1.8	90
A	28	1.8	93
A	35	1.8	93
B	60	1.7	<36
B	120	3.4	<48
C	55	1.5	<78
C	55	3.1	95
D	63	1.9	<79
E	55	1.6	<20
E	110	3.1	<20
F	56	1.6	<67
G	56	1.6	<80
H	55	1.6	<50

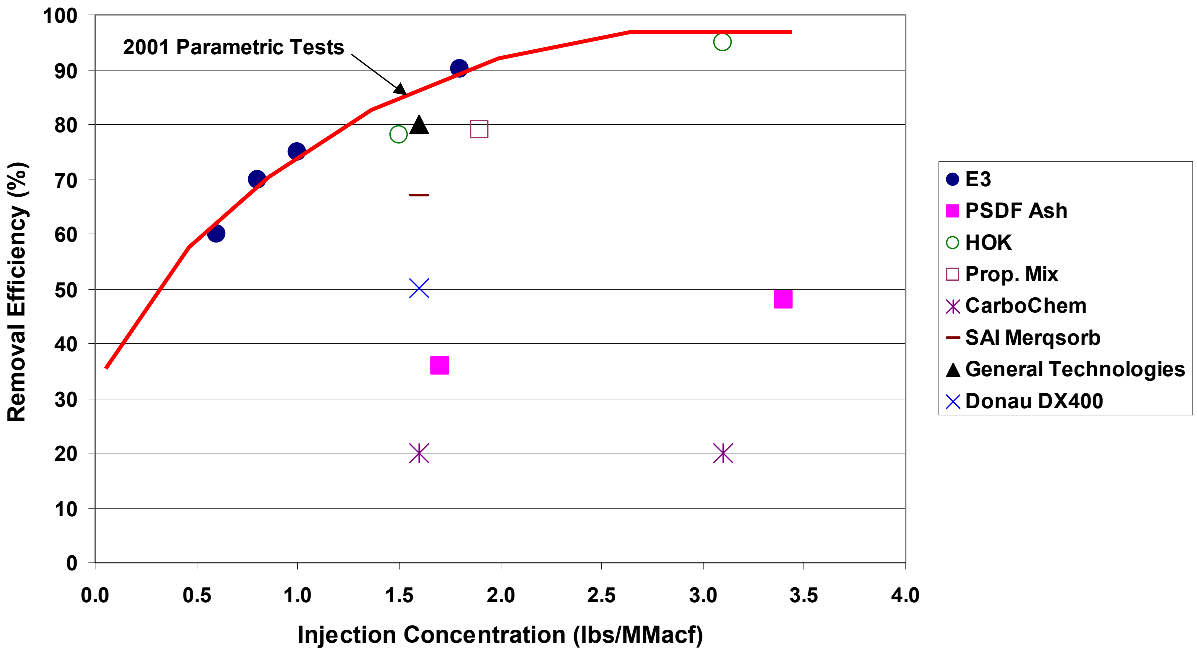

Figure 1. Results from parametric testing of alternative sorbents at Gaston Unit 3B COHPAC®, June 2004.

Appendix A – GFTS Report No. 3789 (Bag Analysis Pre Sorbent Injection)

Grubb Filtration Testing Services, Inc.

8006 Route 130 North
Post Office Box 1156
Delran, NJ 08075

TEL (856) 461-1800
FAX (856) 461-1613
www.GFTS.com

Laboratory Report No. 3789
Date: March 13, 2004

RECEIVED
MAR 18 2004

Prepared For: ADA ENVIRONMENTAL SOLUTIONS, LLC
8100 SouthPark Way, Unit B
Littleton, Colorado 80120

Reference: ADA-ES Agreement No. 007-2002; Task Order No. 01-02-7004

Subject: GASTON UNIT 3B CARBON INJECTION / COHPAC TEST
DOE Cooperative Agreement DE-FC26-02NT41591
Baseline Filter Bag Analysis

Background

Prior to the initiation of the carbon injection test in Casing B of the Gaston Unit 3 COHPAC baghouse, an inspection of the bags was conducted during the Unit 3 outage in March 2003. Information about the bags that were in place at that time is given below. All of the bags were made of 2.7-denier Ryton felt made by Tex Tech Industries.

Modules	Front (3B10 & 3B20)	Rear (3B11 & 3B21)
Bag Supplier	Midwesco	BHA
Date Installed	11/4/00	11/30/01
Length of Service*	18,809 hr	9,678 hr

* Exposure Hours (hours bags exposed to flue gas including time when bypass damper partially opened) from Southern Research Institute summary through March 31, 2003, assuming continuous operation after the outage.

As previously reported by Southern Research Institute, only five "failed" bags were detected (of the 2,194 bags in this casing). Three bags had actually failed in 3B20, and two bags had slipped off their cages in 3B21.

Request and Sample Description

Two used bags, one each from a front and rear module, were submitted for analysis to determine their baseline condition prior to the carbon injection test. They had been removed on March 11, 2003.

Module	Row-Bag	Condition
3B20	15-43	Failed
3B21	8-4	Non-Failed

Bag B20 was a very poor sample for testing due to the massive failure 2-4 feet from its bottom.

Summary and Conclusions

The physical properties of Bag B21 were very similar to those obtained in 1998 on one of the OEM bags with a comparable length of service, as shown in Table 1. (No used bags from either Unit 3 replacement set have previously been tested.) Although the actual Mullen burst strength of the B21 fabric was 30% higher than that of previous used OEM bags from Gaston 3, the percent strength loss was about the same. This is due to the initial strength of the rear module replacement bag fabric, which was 23% greater than that of the OEM bag fabric (525 vs 428 psi, net, normalized to an 18 oz/yd^2 fabric weight).

Since the inside of Bag B20 was severely contaminated with ash due to the massive failure in its bottom, it was unsuitable for permeability and weight testing (except for washed samples). The actual Mullen burst strength of the fabric in this bag was about 15% lower than that of previous used OEM bags from Gaston 3. Since the initial strength of the front module replacement bag fabric was 14% greater than that of the OEM bag fabric (487 vs. 428 psi), the strength loss of the fabric in Bag B20 was even greater relative to that of the OEM bag fabric after a comparable length of service, as shown in Table 1. However, we cannot be certain that the fabric strength was not adversely affected by operation of this bag in its severely failed mode.

The dirty fabric pH (5g/100ml distilled H_2O) was considerably higher (less acidic) on both bags than on previous OEM bags after comparable periods of service.

Table 1

GASTON UNIT 3 – USED BAG COMPARISON
No Carbon Injection

Bag Set	OEM	**Replacement**	OEM	**Replacement**
Date Test Bag Removed	2/20/98	**3/11/03**	1/26/99	**3/11/03**
GFTS Sample	#2587	**#3789-B21**	#2830-A	**#3789-B20**
Service Life	8650 hr	**9678 hr**	16,050 hr	**18,809 hr**
Module	B20	**B21**	A20 / B20	**B20**
Permeability (cfm/ft^2):				
As Received	5.74	**4.78**	–	–
Vacuumed	21.2	**18.8**	–	–
Washed	41.8	**35.4**	–	–
Fabric Weight (oz/yd^2):				
Washed	18.6	**17.8**	18.8	**18.7**
Residual Dust Load (oz/yd^2):				
Removable by Vacuuming	6.1	**6.4**	–	–
Removable by Washing	3.0	**3.0**	–	–
Total (As-Received)	9.3	**9.4**	–	–
Bag Weight, as received (lb)	6.7	**6.9**	6.6	**7.7**
Residual Dust Weight (lb)	2.5	**2.7**	2.4	**3.5**
Mullen Burst Strength (psi, net):				
Average (actual)	318	**396**	322	**271**
Normalized to 18 oz/yd^2	308	**400**	309	**261**
% Loss (vs. new fabric*)	−28%	**−24%**	−28%	**−46%**
Fabric pH (5g/100 ml):	3.44	**4.24**	2.44	**3.97**

* Average values for new fabric were 428, 525, and 487 psi net (normalized) for the OEM bags, the B21 replacement bags, and the B20 replacement bags, respectively.

Observations and Data Profiles

Both bags had been cut into two pieces near their middle and slit open full-length for cage removal. The top sections of both bags were quite stiff (had been wet in service), especially Bag B20, and both had been mangled during removal. Both bags had been "wadded up" in a plastic bag for shipment. The dust cake on both bags was black, which is typical of Gaston ash (though it varies in its degree of blackness).

Bag B21 was in excellent condition with no wear evident, even at the top cuff, cage junction, and bottom reinforcement. The cage wire impressions on the inside of this bag were barely visible at the cage junction or in the bottom half.

Bag B20 had a massive failure and thus was badly contaminated with ash internally. The failure was a 29″ long split starting 13½″ up from the bottom disc. It was at vertical wire #2 (second from the midpoint of the cage, clockwise from the bag seam, top view). The wear at this cage wire, on the *outside* of the bag, was severe, and it extended several feet upward from the split. The bottom reinforcement of this bag was worn completely through, and the bag fabric was worn down to its scrim, at vertical wires #2 and #13, but not yet to the point of failure. The bag was not worn at the cage junction, and in fact the cage impressions were barely visible there.

Since the bags had been cut open and their tops mangled, length and flat width measurements were not possible. The circumference of Bag B21 was 15 3/16″, which is in the range that has been previously measured on numerous used Gaston 3 OEM bags. The circumference of Bag B20 was 15″, which is 1/16″ less than the minimum measured on any previous Gaston 3 bag.

FABRIC WEIGHT AND RESIDUAL DUST LOAD PROFILE (oz/yd^2)

Condition	Bag Section				Average	
	Top		Bottom			
Bag B21						
As-Received	31.7		22.8		27.2	
Vacuumed	23.7	(8.0)	18.0	(4.8)	20.8	(6.4)
Washed	18.6	(5.1)	17.1	(0.9)	17.8	(3.0)
Total Dust Load		13.1		5.7		9.4

Values in ( ) represent dust removed vs. the previous condition; i.e., by vacuuming as-received fabric and by washing vacuumed fabric.

Permeability Profile (cfm / ft^2 @ 0.5″ WG)

Bag Section	As Received			Vacuumed			Washed
	Curved Portions	Flat Portions	Section Average	Curved Portions	Flat Portions	Section Average	
Bag B21							
Top	1.83 / 2.40	3.32 / 3.48	2.76	6.56 / 10.8	7.23 / 9.76	8.56	32.6
Middle	6.02 / 3.99	5.10 / 5.83	5.24	20.7 / 18.7	23.7 / 17.9	20.2	–
Bottom	6.08 / 7.74	6.41 / 5.21	6.36	26.7 / 25.9	29.0 / 23.2	26.2	38.2
Average	4.68	4.89	**4.78**	18.2	18.5	**18.3**	**35.4**

MULLEN BURST STRENGTH PROFILE (psi, net)

Bag Portion	Bag Section			Average
	Top	Middle	Bottom	
Bag B20				
Flat	253 / 274	273 / 235	266 / 292	265
Curved	276 / 339	260 / 226	270 / 289	277
Average	279	249	279	**271**
Bag B21				
Flat	393 / 390	380 / 417	409 / 405	399
Curved	398 / 400	375 / 382	409 / 392	393
Average	395	389	404	**396**

Gross Mullen burst values may be obtained by adding 35 psi (the diaphragm tare pressure) to the net values given above.

Bag Construction

The bags were constructed of 18 oz/yd^2, 2.7-denier Ryton felt, singed on both sides, according to the Hamon Research-Cottrell specifications for the Alabama Power Gaston bags. They had a separate, woven Ryton top cuff with a double-beaded snap band, an oval disk bottom with a 4 reinforcement (both self-material), and a lapped vertical seam sewn with triple needle chain stitching. Both bags were sewn with PTFE thread (blue Profilen) in their circumferential stitching. The vertical seam of Bag B20 (Midwesco) was sewn with multifilament PPS thread, and that of Bag B21 (BHA) with PTFE-coated glass thread.

Appendix B – GFTS Report No. 3919 (Bag Analysis After Sorbent Injection)

Grubb Filtration Testing Services, Inc.

8006 Route 130 North
Post Office Box 1156
Delran, NJ 08075

TEL (856) 461-1800
FAX (856) 461-1613
www.GFTS.com

Laboratory Report No. 3919
Date: December 3, 2004

Prepared For: **ADA ENVIRONMENTAL SOLUTIONS, LLC**
8100 SouthPark Way, Unit B
Littleton, Colorado 80120

Reference: ADA-ES Agreement No. 007-2002; Task Order No. 01-02-7004

Subject: **GASTON UNIT 3B CARBON INJECTION / COHPAC TEST**
DOE Cooperative Agreement DE-FC26-02NT41591
Analysis of Used Filter Bags Removed at End of the Long-Term Test on Original Bags (December 2003)

Background

Information about the bags that were in place at the beginning of the carbon injection test in Casing B of the Gaston Unit 3 COHPAC baghouse in March 2003 is given below. All of the bags were made of 2.7-denier Ryton felt made by Tex Tech Industries.

Modules	Front (3B10 & 3B20)	Rear (3B11 & 3B21)
Bag Supplier	Midwesco	BHA
Date Installed	11/4/00	11/30/01
Length of Service*	18,809 hr	9,678 hr

* Exposure Hours (hours bags exposed to flue gas including time when bypass damper partially opened) from Southern Research Institute summary through March 31, 2003, assuming continuous operation after the outage.

Two used bags, one each from a front and rear module, were removed on March 11, 2003, and submitted for analysis to determine their baseline condition prior to the carbon injection test. (Refer to GFTS Report No. 3789.) At that time, six (6) new bags were installed, three in Module B20 and three in Module B21. These were reported to be 6.0-denier PPS felt bags, "because there were no 2.7-denier bags available."

Request and Sample Description

At the end of the "Long-Term Test on Original Bags", one bag of each type, as described above, was to be submitted for analysis. Five (5) bags were actually submitted (two by mistake), as listed below:

Module	Row-Bag	Length of Service	Condition	Disposition
3B20 3B20	14-24 14-38	25,075 hr 25,075 hr	Mangled Worn but "OK"	Discarded Tested
3B21	14-24	15,944 hr	OK	Tested
3B21 3B21	8-3 8-4	06,266 hr 06,266 hr	Very stiff at top Crusty/Stiff top	Discarded Tested

The bags that were tested are referred to as B20, B21, and 8-4 respectively in this report.

Summary and Conclusions

Except for having somewhat lower permeability values in both their dirty (as-received) and vacuumed conditions, the original replacement bags (B20 and B21) that were exposed to carbon injection during most of their final 6,266 hours of service had properties that were very similar to those of the Gaston 3 OEM bags tested in 1998-2000 after comparable lengths of service without carbon injection, as shown in Table 1 below.

In particular, the activated carbon has had no significant effect on either the fabric strength or pH values. Although the actual Mullen burst strength of the used replacement bags was nearly the same as that of comparably-aged OEM bags from Gaston 3, the percent strength loss was somewhat higher. This is due to the initial strength of the 2.7-denier Ryton replacement bag fabric, which was 14% or 23% greater than that of the 3.0-denier Ryton OEM bag fabric (for the B20 and B21 bags respectively).

Bag 8-4 (Installed in Module B21 in March 2003): This bag was *not a 6-denier PPS bag,* as reported (nor was Bag 8-3). Both were in fact 2.7-denier PPS felt bags from BHA (the same lot as the rear module replacement bags installed in 2001). In addition, portions of both of these bags were very stiff and/or crusty, obviously having been wet in service. The bags that were observed in this area during our March 2003 inspection were in a similar condition and had failed, which is the reason the new bags were installed in this location.

Although neither of these bags was really a suitable specimen, #8-4 seemed to be somewhat less stiff and was selected for testing. The results are given in Table 2 along with data on OEM bags tested after a comparable length of service (without carbon injection) in 1997-98. However, except for the Mullen burst strength, any comparison of the data on Bag 8-4 is probably meaningless due to its atypically stiff and crusty condition.

Table 1

GASTON UNIT 3 – USED BAG COMPARISON
With and Without Carbon Injection

Bag Set	Replace.	OEM	**Replace.**	OEM	**Replace.**
Date Test Bag Removed	3/11/03	8/9/98	**12/6/03**	11/30/99	**12/6/03**
GFTS Sample	#3789-B21	#2725	**#3919-B21**	#3087	**#3919-B20**
Service Life	9678 hr	12,176 hr	**15,944 hr**	23,815 hr	**25,075 hr**
Carbon Injection?	No	No	**Yes***	No	**Yes***
Module	B21	A10	**B21**	A20/B20	**B20**
Permeability (cfm/ft^2):					
As Received	4.78	4.48	**3.07**	3.60	**3.21**
Vacuumed	18.8	15.8	**11.7**	14.4	**12.6**
Washed	35.4	40.9	**33.0**	40.4	**31.0**
Fabric Weight (oz/yd^2):					
Washed	17.8	18.6	**18.2**	19.4	**19.2**
Residual Dust Load (oz/yd^2):					
Removable by Vacuuming	6.4	5.6	**4.7**	6.8	**4.8**
Removable by Washing	3.0	5.3	**6.0**	7.1	**4.2**
Total (As-Received)	9.4	10.9	**10.7**	13.9	**9.0**
Bag Weight, as received (lb)	6.9	6.8	**6.6**	7.4	**6.4**
Residual Dust Weight (lb)	2.7	2.6	**2.4**	3.1	**2.2**
Mullen Burst Strength (psi, net):					
Average (actual)	396	343	**357**	305	**305**
Normalized to 18 oz/yd^2	400	332	**354**	283	**286**
% Loss (vs. new fabric**)	−24%	−23%	**−33%**	−33%	**−41%**
Fabric pH (5g/100 ml):	4.24***	3.03	**2.91**	2.45	**2.57**

* During much of the final 6,266 hours of service

** Average values for new fabric were 428, 525, and 487 psi net (normalized) for the OEM bags, the B21 replacement bags, and the B20 replacement bags, respectively.

*** pH electrode malfunction suspected

Table 2

GASTON UNIT 3 – USED BAG COMPARISON

With and Without Carbon Injection

Bag Set	OEM	**Test Bag***	OEM
Date Test Bag Removed	10/3/97	**12/6/03**	2/20/98
GFTS Sample	#2460	**#3919-8-4**	#2587
Service Life	6,100 hr	**6,266 hr**	8,650 hr
Carbon Injection?	No	**Yes**	No
Module	A20	**B21**	B20
Permeability (cfm/ft^2):			
As Received	6.32	**3.38**	5.74
Vacuumed	18.6	**13.2**	21.2
Washed	42.7	**32.4**	41.8
Fabric Weight (oz/yd^2):			
Washed	18.1	**18.1**	18.6
Residual Dust Load (oz/yd^2):			
Removable by Vacuuming	3.4	**7.15**	6.1
Removable by Washing	3.8	**14.2**	3.0
Total (As-Received)	7.2	**21.35**	9.3
Bag Weight, as received (lb)	6.0	**7.2**	6.7
Residual Dust Weight (lb)	1.8	**3.0**	2.5
Mullen Burst Strength (psi, net):			
Average (actual)	358	**357**	318
Normalized to 18 oz/yd^2	357	**355**	308
% Loss (vs. new fabric**)	−17%	**−32%**	−28%
Fabric pH (5g/100 ml):	4.45	**3.17**	3.44

* Installed in March 2003 prior to initiation of the carbon injection test. This used bag was very stiff and crusty, atypical of Gaston 3 bags in general.

** Average values for new fabric were 428 and 525 psi net (normalized) for the OEM bags and the B21 test bag, respectively.

Bag Measurements and Construction

Used Bag	**B20**	**B21**	**8-4**
Length (inches)*	–	277 3/8	277 1/4
Flat Width (inches)	7 3/8	7 7/16	7 7/16
Circumference (inches)	14 7/8	14 15/16 – 15	14 15/16 – 15
Bag Weight (lb)	6.39	6.58	7.16

* Measured at the seam, from top of bag to the upper row of disc stitching. Bags cut in half as-received; sum of lengths of two pieces. Bag B20 too damaged during removal to measure accurately.

The bags were constructed of 18 oz/yd^2, 2.7-denier Ryton felt, singed on both sides, according to the Hamon Research-Cottrell specifications for the Alabama Power Gaston bags. They had a separate, woven Ryton top cuff with a double-beaded snap band, an oval disk bottom with a 4″ reinforcement (both self-material), and a lapped vertical seam sewn with triple-needle chain stitching. Both bags were sewn with PTFE thread (blue Profilen) in their circumferential stitching. The vertical seam of Bag B20 (Midwesco) was sewn with multifilament PPS thread, and those of Bags B21 and 8-4 (BHA) were sewn with PTFE-coated glass thread.

Observations and Data Profiles

All of the bags had been cut into two pieces and slit open vertically near their middle for cage removal. The external dust cake on all bags was the same dark gray color, but it varied from bag to bag in its thickness and appearance.

Bag 8-3: This bag had a very nodular dust cake, and it was very stiff and crusty in its top 2 1/2 feet. It was discarded.

Bag 8-4: This bag also had a very nodular dust cake, especially in its bottom half, but its top was not nearly as stiff as that of #8-3. The top 5-foot section of this bag was much stiffer than the rest of the bag, and it had blotchy staining (watermarks?). It was still very stiff and crusty even after vacuuming. There were no signs of excessive wear on this bag, either internally or externally. Internally, the bag was a light olive color, with not much of a color gradient from top to bottom (unusual for Gaston bags), and it appeared to be much newer than Bags B20 and B21 (as it was supposed to be). The cage pan impression, though somewhat indistinct, was ≈ 1 1/4″ above the bag disc.

Bag B21: This bag had a similar appearance to #8-4 except that it was not stiff. It had some soft crust externally, especially in the curved portions in its top half, but no hard nodules like #8-4. There were no signs of excessive wear, either internally or externally. This bag had more blotchy dust darkening internally than #8-4, especially in the flat portion of its bottom half. The cage pan impression was level with to slightly above the bag disc.

Bag B20: The external dust cake on this bag was more flaky, not crusty or nodular like the other bags. It had been mangled somewhat in its top cuff and near its middle during removal. *Its bottom reinforcement was badly worn,* completely through to the bag fabric in the flat portion on the seam side and down to the scrim of the bag fabric in one curved portion. Although the thread in the disc attachment stitching was worn away externally in that curved section, no actual dust leakage had occurred. This type of wear is common in certain areas of the front modules in this baghouse, where bags swing and bang together due to turbulent gas flow. The bag exhibited no excessive wear otherwise, either internally or externally. The cage pan impression was bottomed out in the bag disc.

The washed samples of all three bags were a light golden-brown color (with some carbon staining externally), typical of previous used Gaston bags. The washed samples from Bag B20 (the oldest bag) were only slightly darker in color.

Permeability Profiles

Used Bag		B20	B21	8-4
Permeability (cfm/ft^2 @ 0.5″ WG):				
As Received,	Top	2.20	2.53	3.18
	Middle	3.78	3.00	3.43
	Bottom	3.66	3.68	3.54
	Average	3.21	3.07	**3.38**
Vacuumed,	Top	6.34	5.84	5.20
	Middle	15.0	11.5	15.5
	Bottom	16.6	17.8	18.9
	Average	12.6	11.7	**13.2**
Washed,	Top	29.2	29.8	32.3
	Bottom	32.8	36.3	32.4
	Average	31.0	33.0	**32.4**

Mullen Burst Profiles

Used Bag		B20	B21	8-4
Mullen Burst (psi, net):				
Vacuumed,	Top	296	359	362
	Middle	307	374	359
	Bottom	324	346	422
	Average	309	359	**381**

Fabric Weight and Residual Dust Load Profiles (oz/yd^2)

Used Bag			B20	B21	38202
Weight (oz/yd^2):					
	As-Received,	Top	30.1	32.0	47.4
		Bottom	26.3	25.9	31.5
		Average	28.2	28.95	39.45
	Vacuumed,	Top	25.4	26.7	41.3
		Bottom	21.4	21.8	23.3
		Average	23.4	24.25	32.3
	Washed,	Top	19.8	18.6	17.7
		Bottom	18.6	17.9	18.5
		Average	19.2	18.25	**18.1**
Residual Dust Load (oz/yd^2):					
	Removed by vacuuming,	Top	4.7	5.3	6.1
		Bottom	4.9	4.1	8.2
		Average	4.8	4.7	**7.15**
	Removed by washing,	Top	5.6	8.1	23.6
		Bottom	2.8	3.9	4.8
		Average	4.2	6.0	**14.2**
	Total	Top	10.3	13.4	29.7
		Bottom	7.7	8.0	13.0
		Average	9.0	10.7	**21.35**

Fabric pH

pH was measured on samples of as-received (dirty) fabric from the middle of both bags (5 g per 100 ml distilled water). The values were 2.57, 2.91, and 3.17 for bags B20, B21 and 8-4 respectively.